Karen Founk, Shannon Mendes

Curriculum Topic Review
SCH4U – Energy Changes and Rates of Reaction

Activity: Using Bingo to Review Formula: Q=cmΔT

Ministry Expectations

- D2.1 use appropriate terminology related to energy changes and rates of reaction, including, but not limited to: enthalpy, activation energy, endothermic, exothermic, potential energy, and specific heat capacity [C]
- D2.3 Solve problems involving analysis of heat transfer in a chemical reaction, using the equation $Q = mc\Delta T$ (e.g., calculate the energy released in the combustion of an organic compound, and express the results in energy per mole of fuel [J/mol]) [AI, C]

Learning Goals

- Students will review key terms (exo/endothermic, enthalpy, specific heat capacity, etc)
- Students will write thermochemical equations, expressing the energy changes as a ΔH value or as a heat term in the equation
- Students will work together to solve problems using Q=cmΔT

Teacher Instructions

1. Divide students into bingo families/teams (6 people per group):
    - Distribute cards to students (**Appendix A**)
    - Ask students to get into groups based on the category of enthalpy change represented on the card they received.
    - E.g., students could form 1 group based on the theme of combustion:
        - Molar Enthalpy of Combustion
        - ΔH^o_{comb}
        - $C_4H_{10(g)} + 13/2\ O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)} + 2871\ kJ$
        - $C_4H_{10(g)} + 13/2\ O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)} \quad \Delta H^o = -2871\ kJ$
        - Enthalpy change when 1 mol of substance is completely burned in O_2.
        - The burning of wood
2. Guide students as they review key concepts using bingo:
    - Distribute bingo instructions, questions and cards to students (**Appendix B-C**)
    - Ask one member from each team to close their eyes and randomly pick a question
    - Students will read out question to bingo family and solve question as a team
    - Once the question is solved, students will look for the answer on their BINGO sheet and put the number of the question in the box with the answer
    - The aim of the game is to get "four boxes in a row", horizontally, vertically or diagonally

Appendix A: Cards for Sorting Students into Bingo Groups

Molar Enthalpy of Combustion	Enthalpy change when 1 mole of a substance is completely burned in oxygen
ΔH^o_{comb}	E.g. The burning of wood
$C_4H_{10(g)} + 13/2\ O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)} +$ 2871 kJ	ΔH^o_{comb} = -2676 kJ/mol butanol

Molar Enthalpy of Formation	Enthalpy change for the formation of one mole of a compound from its elements
ΔH^o_f	$C_{(s)} + 2H_{2(g)} + ½O_{2(g)} \rightarrow CH_3OH_{(l)}$ ΔH^o_f = -239.1 kJ
$2C_{(s)} + 3H_{2(g)} + ½\ O_{2(g)} \rightarrow C_2H_5OH_{(l)}$ + 235 kJ	ΔH^o_f = -1273.1 kJ/mol glucose

Molar Enthalpy of Solution	Enthalpy change when 1 mole of a solute is dissolved in a solvent
ΔH^o_{sol}	E.g. The temperature drops 5°C when 7.46g of KCl is dissolved in 100.0 mL
$KCl_{(s)} + 17\ kJ \rightarrow K^+_{(aq)} + Cl^-_{(aq)}$	$KCl_{(s)} \rightarrow K^+_{(aq)} + Cl^-_{(aq)} \quad \Delta H^o_{sol} = +17\ kJ$

Molar Enthalpy of Neutralization	Enthalpy change when 1 mole of acid is neutralized
$\Delta H^o_{neut} = -57.5$ kJ/mol NaOH	The temperature rises when 10.0mL of 1.0M NaOH is added to 10.0mL of 1.0M H_2SO_4
$NaOH_{(aq)} + \frac{1}{2} H_2SO_{4(aq)} \rightarrow \frac{1}{2} Na_2SO_{4(aq)} + H_2O_{(l)} + 57.5\ kJ$	$NaOH_{(aq)} + \frac{1}{2} H_2SO_{4(aq)} \rightarrow \frac{1}{2} Na_2SO_{4(aq)} + H_2O_{(l)}$ $\Delta H^o_{neut} = -57.5$ kJ

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Appendix B: Bingo Questions (Teacher copy)

1. What is the temperature change of a 120g piece of aluminum whose specific heat is 1.89 J/g°C after 1800 J of heat energy is applied?

$1800 = 120 \times 1.89 \times \Delta T$
$\Delta T = 7.94\ ^{o}C$

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2. 1.0 g of sodium hydroxide, NaOH, was added to 99.0 g of water. The temperature of the solution increased from 18.0 to 20.5 °C. The specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}. Which expression gives the heat evolved in kJ mol^{-1}?

A. $\frac{(2.5 \times 100.0 \times 4.18 \times 1000)}{40.0}$

B. $\frac{(2.5 \times 100.0 \times 4.18)}{(1000 \times 40.0)}$

C. $\frac{(2.5 \times 100.0 \times 4.18 \times 40.0)}{1000}$

D. $\frac{(2.5 \times 1.0 \times 4.18 \times 40.0)}{1000}$

---

3. What is the specific heat capacity of a substance (in cal/g °C) if 400 calories cause 25g of it to go from 60°C to 190°C?

$Q = 400$ cal, $m = 25$ g
$Q = mc(T_f — T_i)$
$c = 0.12$ cal/g°C

---

4. What was the initial temperature if 250 calories were applied to 100g of gold and the final temperature of the gold was 175°C? The specific heat capacity of gold is 0.031 cal/g°C.

$Q = 250$ cal, $m = 100$ g, $c = 0.031$ cal/g°C , $T_f = 175$°C, $T_i = ?$
$Q = mc(T_f — T_i)$
$250\ cal = (100\ g)\ (0.031\ cal/g°C)(175°C - T_i)$
$T_i = 94$°C

5. The mass *m* (in g) of a substance of specific heat capacity *c* (in J g^{-1} K^{-1}) increases by *t* (^{o}C). What is the heat change in J?

A. *mct*
B. $mc(t + 273)$
C. $\frac{mct}{1000}$
D. $\frac{mc\,(t + 273)}{1000}$

---

6. What is the final temperature if 500 calories are applied to 40 grams of copper at 20°C? The specific heat capacity of copper is 0.092 cal/g°C.

$Q = mc(T_f - T_i)$ $T_f = 156\ ^{o}C$

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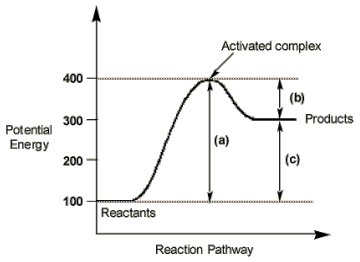
7. Draw a diagram of an energy level potential diagram for an endothermic reaction.



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8. What is the molar heat capacity of ethyl alcohol, C_2H_5OH, in units of J/mol^{o}C, if its specific heat is 0.586 cal/g ^{o}C? *[Recall: There are 4.18 Joules per calorie]*

$\frac{0.586\ cal}{g\ ^{o}C} \times \frac{4.18J}{1\ cal} \times \frac{46.08g}{mol}$ = **112.9 J mol^{-1} $^{o}C^{-1}$**

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9. When 8.0 g of ammonium nitrate (NH_4NO_3) was dissolved in 100 mL of water the temperature fell from 19.0 C to 14.5 C. Calculate the molar enthalpy of solution for ammonium nitrate.

$Q = cm\Delta T = 4.18J\ mol^{-1}\ ^{o}C^{-1} \times (100g) \times (14.5\text{-}19.0\ ^{o}C) = -1881\ J$

$\Delta H_{system} = -|q_{surroundings}| = -(-1881J) =$ endothermic

$\Delta H_{NH3NO3} = \frac{1881J}{8.0g \times (mol/80.04g)}$

$= 18819.405J = +$**19 kJ**

10. A laboratory technician adds 43.1 mL of concentrated, 11.6 mol/L hydrochloric acid to water to form 500.0 mL of dilute solution. The temperature of the solution changes from 19.2C to 21.8C. Calculate the molar enthalpy of dilution of hydrochloric acid in kJ/mol. (4 marks)

$Q = cm\Delta T$
$= 4.18 J\ g^{-1}\ ^oC^{-1}\ \times\ (500g)\ \times\ (21.8\text{-}19.2\ ^oC) = 5434\ J$

$\Delta H_{system} = -|q_{surroundings}|$
$= -(5434J) = \text{exothermic}$

$\Delta H_{HCl} = \frac{5434J}{(11.6\ mol^{-1}\ L^{-1})(43.1\ mL)\ (1L/1000mL)} = \mathbf{-10.9\ kJ/mol}$

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11. Consider the following equation for the combustion of hydrogen:

$$H_2(g) + \tfrac{1}{2}\ O_2(g) \rightarrow H_2O(g) + 243\ kJ$$

In order to produce 1215kJ of heat, how many grams of H_2 must burn?

10.0 g

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12. If a 2.34g substance at 22°C with a specific heat of 3.88 cal/g °C is heated with 124 cal of energy, what is the new temperature of the substance?

$Q = cm\Delta T$
$124\ cal = 3.88\ cal\ g^{-1}\ ^oC^{-1}\ \times\ (2.34g)\ \times\ (T_f\text{-}22\ ^oC)$
$T_f = 35.7\ ^oC$

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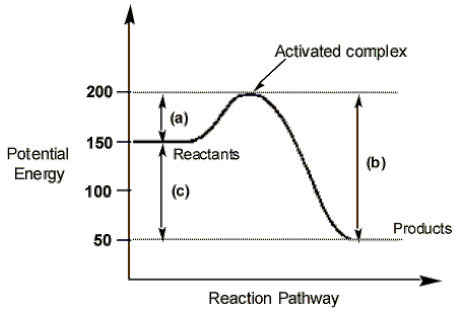
13. Draw a diagram of an energy level potential diagram for an exothermic reaction.



14. Which types of reactions are always exothermic?

I. Neutralization
II. Decomposition
III. Combustion

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

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15. How many grams of aluminum can be heated from 90°C to 120°C if 500 calories are applied? The specific heat of aluminum is 0.21 cal/g°C.

Q = 500 cal, m = ?, c = 0.21 cal/g°C, Tf = 120°C, Ti =90°C

Q = mc(Tf—Ti)
500 cal = (m) (0.21 cal/g°C)(120—90°C)
m = 79.4g

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16. When the solids $Ba(OH)_2$ and NH_4SCN are mixed, a solution is produced and the temperature drops.

$$Ba(OH)_2(s) + 2NH_4SCN(s) \rightarrow Ba(SCN)_2(aq) + 2NH_3(g) + 2H_2O(l)$$

Which statement about the energetics of this reaction is correct?

A. The reaction is endothermic and ΔH is negative.
B. The reaction is exothermic and ΔH is negative.
C. The reaction is exothermic and ΔH is positive.
D. The reaction is endothermic and ΔH is positive.

Appendix B: Bingo Questions (Student copy)

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4. What was the initial temperature if 250 calories were applied to 100g of gold and the final temperature of the gold was 175°C? The specific heat capacity of gold is 0.031

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5. The mass m (in g) of a substance of specific heat capacity c (in J g^{-1} K^{-1}) increases by t (^{o}C). What is the heat change in J?

A. mct

B. $mc(t + 273)$

C. $\frac{mct}{1000}$

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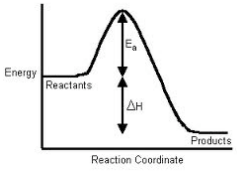
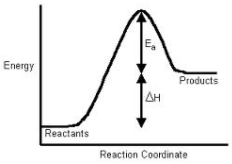
A. The reaction is endothermic and ΔH is negative.
B. The reaction is exothermic and ΔH is negative.
C. The reaction is exothermic and ΔH is positive.
D. The reaction is endothermic and ΔH is positive.

Appendix C: Bingo Cards

BINGO INSTRUCTIONS:

1. Now that you have found your BINGO family, one member from your team will close their eyes and randomly pick a question from the cup
2. Read out the question to your family and as a team solve the question
3. When you have solved the question, look for the answer on your BINGO sheet and put the number of the question in the box with the answer
4. The aim of the game is to get "four boxes in a row", horizontally, vertically or diagonally.

BINGO CARD 1:

7.94°C	**35.7°C**	**0.12 cal/g°C**	**94°C**
79.4g	**156°C**		
112.9 J mol^{-1} $^oC^{-1}$	**19 kJ**	**10.0 g**	**A**
C	**B**	**D**	**-10.9 kJ/mol**

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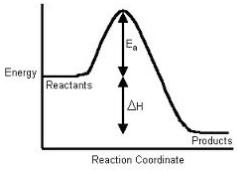
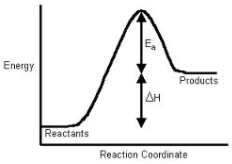
BINGO CARD 2:

10.0 g	**112.9 J mol^{-1} $^oC^{-1}$**	**19 kJ**	**A**
0.12 cal/g°C	**7.94°C**	**35.7°C**	**94°C**
	**79.4g**	**156°C**	
D	**C**	**B**	**-10.9 kJ/mol**

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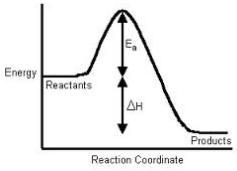
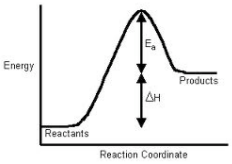
BINGO CARD 3:

19 kJ	**112.9 J mol^{-1} $^oC^{-1}$**	**10.0 g**	**A**
35.7°C	**7.94°C**	**0.12 cal/g°C**	**94°C**
156°C	**79.4g**		
B	**C**	**D**	**-10.9 kJ/mol**

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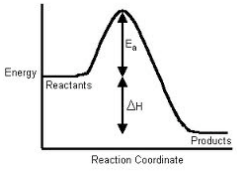
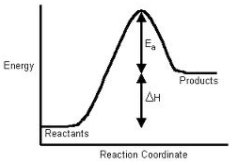
BINGO CARD 4:

B		**C**	**10.0g**
79.4g	**156°C**	**35.7°C**	
112.9 J mol^{-1} $^oC^{-1}$	**D**	**94°C**	**A**
0.12 cal/g°C	**7.94°C**	**19 kJ**	**-10.9 kJ/mol**

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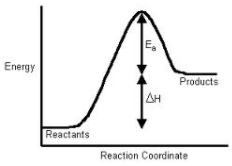
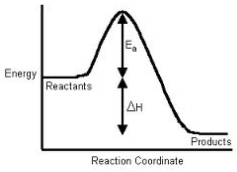
BINGO CARD 5:

A	**D**		**94°C**
112.9 J mol^{-1} ^{o}C^{-1}		**156°C**	**0.12 cal/g°C**
79.4g	**B**	**10.0 g**	**7.94°C**
C	**19 kJ**	**35.7°C**	**-10.9 kJ/mol**

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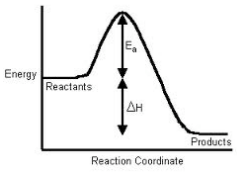
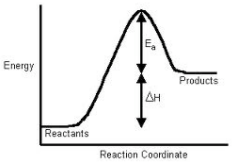
BINGO CARD 6:

7.94°C	**35.7°C**	**C**	**A**
79.4g	**156°C**		**-10.9 kJ/mol**
B	**19 kJ**	**D**	**94°C**
0.12 cal/g°C	**112.9 J mol^{-1} ^{o}C^{-1}**	**10.0 g**	

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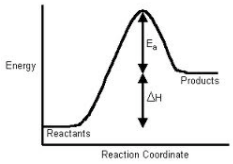
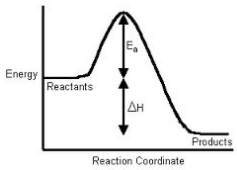
BINGO CARD 7:

D	**35.7°C**	**B**	**94°C**
79.4g	**156°C**	**C**	**10.0g**
A	**19 kJ**		**112.9 J mol^{-1} ^{o}C^{-1}**
	**0.12 cal/g°C**	**7.94°C**	**-10.9 kJ/mol**